

# A study on corporate operational sustainability of DHI companies in Bhutan: Using TFP approach

Dr. Elangbam Haridev Singh<sup>1\*</sup> & Tshewang Dorji<sup>2</sup>

<sup>1</sup>Associate Professor, School of Business Management, St. Joseph University, Nagaland, India. <sup>2</sup>Lecturer, Gedu College of Business, Royal University of Bhutan, Gedu, Chukha, Bhutan. Corresponding Author Email: haridevelang@gmail.com\*



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## ABSTRACT

The aim of the article is to evaluate the corporate sustainability performance at operational level of eight homogeneous DHI companies of Bhutan over the period 2015 to 2018. An assessment of operational sustainability is essential for assessing and improving the productivity and performance of companies. Data envelopment analysis using Malmquist productivity index has been applied to measure the total factor productivity (TFP) and its components: pure technical efficiency, technological efficiency and scale efficiency. DHI companies are considered to transform their inputs (annual expenditure, number of employees and annual donations) into outputs (cost saving and profit). The model considered is the input-oriented Malmquist productivity index under the variable return to scale. Data were collected from the published annual reports of the companies. The overall productivity progressed in four companies. The overall changes in pure technical efficiency and scale efficiency have progressed with 11.6 percent and 7.2 percent, respectively. The overall technological efficiency change has regressed with 14.4 percent. Thus, the overall productivity growth in DHI companies are mainly attributed to technical improvements and not to technological advancements. The technological inefficiency was the main source of inefficiency in DHI companies.

**Keywords:** DEA; TFP; Sustainability; Bhutan; DHI; Efficiency; Malmquist productivity index; Pure technical efficiency; Technological efficiency; Technological inefficiency.

## 1. Introduction

Corporate sustainability is a philosophy that the survival of a company should look beyond financial and operational excellence and focus on maintaining present resources without endangering the resources for future generations. The organizations should be able to meet the all the stakeholder's intake standards (Neubaum & Zahra, 2006). The term 'sustainable' prefixed with corporate mean a business model that maintains the current practices without depleting the resources for future. According to the Brundtland commission, sustainable development is defined as, "To meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 41). In Bhutan, the idea of sustainability is not new as it is very intrinsic to the core philosophy of GNH (Yanka et al., 2018). Lee and Saen (2012), highlights the significance of Corporate sustainability measurement for economic competitiveness and reduction of risk for company. Company's competitiveness and financial success can be affected if the CS activities are not integrated in the company's overall business strategy. Further, it appears that the best decisions can only be made when the financial, environmental and social impacts are taken into consideration (Hockerts, 1999). As DHI companies were established to uphold and manage the existing and future investments of the Bhutan for the long term benefit of the people, measuring the corporate sustainability performance can fill the knowledge gap of the current state of DHI owned companies in managing corporate sustainability. Despite the increased awareness of the conceptual and functional meaning of corporate sustainability, corporate sustainability practices are not well established or adopted within the business community of Bhutan. A study was conducted by Sebastian to discuss about sustainability efforts and GNH impact on business community in Bhutan (Sebastian, 2015). The study found that corporate social responsibility (CSR) and CS applications are not well established and business recognition of these principles and

sustainability reporting are much rarer in the business community of Bhutan. Moreover, CS activities can help DHI companies to operationalize GNH value as there is an indisputable positive relationship between corporate social performance and Gross National Happiness. Ura, Alkire, Zangmo and Wangdi noted (as cited in Zangmo et al., 2017), “GNH framework proposes instead, an inclusive, holistic, equitable, sustainable, and balanced development for societal wellbeing”. The GNH principles can be a guide to direct businesses to operate in a socially responsible manner and to work towards addressing social, cultural and environmental problems. Besides, if business partners can be identified and ranked in economic, social and environmental terms on the basis of their sustainability performance, it can help a company to mitigate its sustainability risk. Overall, if managers are aware of the company’s stand in managing corporate sustainability, this can help them to align their corporate and business strategies and to meet key sustainability challenges.

### 1.1. Objectives of the study

- (i) Assess the operational level sustainability performance of eight homogeneous DHI companies in Bhutan from 2015 to 2018.
- (ii) Determine the importance of operational sustainability in enhancing the productivity and performance of companies.
- (iii) Use Data Envelopment Analysis (DEA) and the Malmquist productivity index to measure the Total Factor Productivity (TFP) and its components: pure technical efficiency, technological efficiency, and scale efficiency.
- (iv) To see the performance of companies for over more than one year and to contrast the company’s performance metrics, efficiency change and technical change.

## 2. Literature Review

The literature is organized around two broad themes: corporate sustainability and the method of measuring corporate sustainability. The term "sustainability" is derived from Brundtland's definition of sustainable development (Frecè & Harder, 2018; Amini & Bienstock, 2014). Further Gladwin et al. (1995) defined 'sustain centrism' in the corporate world as a connected, equitable, prudent, and risk-free human development model. Shrivastava (1995) and Starik and Rands (1995) defined 'ecological sustainability' as a corporate strategy that addresses environmental sustainability issues through competitive strategies such as technology for environmental conservation and corporate impact management to ensure the sustainability of business enterprises. Corporate sustainability is defined as an organizational strategy focused on achieving economic goals with social equity while minimizing environmental impact, including the three Ps (profit, people, and planet) (Szekelely and Knirsch's, 2005; Bansal 2005; Hart & Mistien, 2003). In 2006, Schaltegger and Wagner (2006) defined corporate sustainability management functionally as well as institutionally. Corporate sustainability management, from a functional perspective, aims to manage social, economic, and environmental effects of business operations in a way that promotes the growth of enterprises in a sustainable manner. From an institutional perspective, corporate sustainability management refers to the management and organizational structure of a corporation operating to integrate social and environmental aspects into traditional business operational practices. Dow Jones Sustainability Indexes (2009) described corporate sustainability as a business strategy that increases the value of shareholder by

enhancing business opportunities and minimising risks associated with economic, social, and environmental advancements. According to Porritt (2007), corporate sustainability is the management strategy for resolving all environmental, social, and economic issues that emerge from the implementation of sustainable development practices.

In the current scenario, sustainability has become a major issue for the industries and economies of the nation. The businesses will be unable to sustain themselves if the sustainability issue is not effectively addressed. Kraus and Britzelmaier (2012) stated that the firm's success is driven by social and environmental factors embedded in CS practices of the firm. Furthermore, enhanced social and ecological performance is considered as a competitive advantage for a business because it can bring improvements in output productivity, cost compliance, and market avenues (Schaltegger & Wagner, 2006). According to Weber (2008), the probable benefits of CS can be monetary or non-monetary. Monetary benefits include only financial rewards, while non-monetary benefits cannot be directly quantified in financial terms. A company's competitiveness and financial success are affected indirectly or directly by the CS management practices. A company can achieve maximum benefit, if the CS activities are integrated into the overall business strategy.

Moreover, Epstein (2008) cites four reasons why CS requires immediate attention. Companies are required to attend CS for four main reasons which includes: the responsibility to adhere to the government regulatory standards and industrial codes in order to address sustainability; community engagement in order to address social and environmental problems and to enhance business credibility; cost and revenue sustainability of a company in order to increase the financial revenue by lowering costs and increasing profits; and societal and moral obligations to maintain CS. Moreover, the company managers may develop an appropriate sustainability strategy, set up aligned structure, and take specific action to resolve the sustainability risk (risk arising from environmental and social impacts). Furthermore, based on their CS performance, businesses can integrate with compatible corporations to reduce the risk of sustainability. Finally, managing sustainability means becoming a better corporate citizen and constantly striving for a more sustainable future.

## **2.1. Corporate sustainability and GNH in Bhutan**

The most inherent issue in incorporating CS is how one defines it and implements it. The BCCI study (as cited in Lhaden, 2010) found that CSR to the Bhutanese mind means sponsoring, financing or contributing to individuals or organizations that are not part of the company's structure. Bhutan CSR 2013 guidelines offer a practical approach for incorporating CSR into business organizations, however, CSR policies are not mandatory for all business. However, the Companies Bill of Bhutan, 2014 established the first legal CSR requirement to embed CSR practices into their operations. This annual reporting system requires member companies to highlight on corporate governance policy and CSR (RGoB, 2014, p. 53). However, these efforts appear insignificant to business participants and leaders. Sebastian (2015) discovered that companies in Bhutan do not report CSR due to a lack of proper legal obligations and inadequate documentation (Sebastian, 2015). Furthermore, a CSR perception study conducted by BCCI in 2013 (as cited in Sebastian, 2015) reveals that CSR is not embedded in the corporate strategy of Bhutanese business corporations. Lhaden (2010) confirmed that 47 per cent of public business corporations

experienced conflicts mainly due to unfairness and discrimination. It was also discovered that 91 per cent of respondents did not report unethical business practices because there was no formal legislation or rules governing the business practices (Lhaden, 2010).

The business corporations in Bhutan are mandated to incorporate corporate sustainability management because of the importance and the scope to develop sustainable economy aligned to Gross National Happiness. The CSR constitute three main pillars of GNH: the environment, sustainable development, and good governance. Sebastian (2015) discovered that GNH, CSR, and CS are not well founded or implemented in the business sector of Bhutan. In comparison to the concepts of CSR and CS, Sebastian (2015) claims that the GNH model of business in Bhutan provides an all-inclusive approach to the development of sustainable business. However, CSR and CS applications can be applied to the business practices of Bhutan to operationalise GNH.

## **2.2. Measuring corporate sustainability (CS)**

The study presents both materials and methods for measuring the corporate sustainability. An available literatures presents the ambiguity of the dimension and metrics about measuring CS (Montiel & Delgado-Ceballos, 2014; Barba-Gutierrez et al., 2008; Briassoulis, 2001). Generally, researchers employ pre-existing constructs and dimension such as Kinder, Lydenberg, and Domini (KLD) and the Global reporting initiative (GRI), which employs three economic indicators, four social indicators, and eight indicators in environment (Bos-Brouwers, 2009; Weber, 2011). The Dow Jones Sustainability Index (DJSI) employs seven economic indicators, six social indicators and three environmental indicators (Kurapatskie and Darnall 2012; Cheung, 2010; Maas and Liket, 2010). The economic indicators are: “risk and crisis management”, “corporate governance”, “customer relationship management”, “conduct and compliance”, “supply chain management”, “brand management”, “privacy protection”, “supply chain management”, “privacy protection”; the social indicators are: “human rights and human capital development”, “social reporting”, “corporate citizenship philanthropy”, “stakeholder engagement”, “labour practices”, “talent attraction and retention”; and environment indicator covers: “operational eco-efficiency”, “environmental policy”, and “environmental reporting” (Kurapatskie & Darnall 2012; Cheung, 2010; Maas & Liket, 2010).

Some researchers create their own constructs, as highlighted by Bansal (2005) and Kolk et al. (2008). It is still difficult to implement these constructs at firm level (Labuschagne et al., 2005) due to lack of comprehensive framework to assess at organisational level (Singh et al. 2007), and moreover, it only serve as a guideline, suggestion and recommendation on how to incorporate CSM to achieve company’s goals (Lee and Saen, 2011). At the operational level, eco-efficiency (the ratio of environment costs to economic output) has been proven to be an effective tool for measuring corporate sustainability (Lee and Saen, 2011; Michelsen et al., 2006). Using eco-efficiency indicators and Data Envelopment analysis (DEA) method, we employed the framework applied by Lee and Sean (2012) to measure corporate sustainability at the operational level. The DEA method is applied to evaluate the productivity of the decision making units (DMUs) using the multiple performance metrics. The linear programming methods are an essential component of DEA. The concept of efficiency frontiers procedures is used by DEA to evaluate the performance of DMUs (companies or organisations).

The above literatures measure the sustainability of corporations using DEA cross efficiency method (Lee & Saen, 2012). The study examines the changes in the organisational efficiency of DHI-owned companies in Bhutan using Malmquist Productivity Index (VRS-input model). Malmquist Productivity Index (MPI) is the best method for estimating productivity index and for efficiency measurement (Coelli, 2008).

### 3. Methodology

#### 3.1. Data Envelopment Analysis Concepts

DEA is a popular method for estimating the efficiency of a group of decision making units by comparing the ratio of weighted output to input (Avkiran, 2007). In the DEA method, the organizational entities or units under study are referred to as decision making units (DMUs). The optimal set of input and output weights for each DMUs are obtained by applying linear programming technique to the objective data (Cooper, Seiford & Zhu, 2011). The main objective of DEA is to perform an efficiency frontier analysis for a group of DMUs using the input and output variables. The relative efficiency of each DMU is evaluated by contrasting its original input and output variables to the projected data on the efficiency frontier (Li et al., 2020). The CCR (Charnes, Cooper, and Rhodes) DEA was the first DEA model, introduced in 1978 by Charnes, Cooper, and Rhodes (1978). Banker, Charnes, and Cooper (1984) extended the CCR DEA further in 1984 by incorporating the linear programming method to evaluate the relative efficiency of DMUs. Many scholars have proposed different forms of DEA models since the introduction of the DEA method, including the cross-efficiency model (Sexton, Silkman, & Hogan, 1986; Doyle & Green, 1994), SBM model (Tone, 2001), network structured model (Färe and Grosskopf, 1996), dynamic efficiency model (Charnes & Cooper, 1984), meta-frontier model (Battese et al., 2004), and so on.

We have two fundamental DEA models: the CCR (Charnes, Cooper, and Rhode) DEA model and BCC (Banker, Charnes, and Cooper) DEA model. The CCR model is based on the constant return to scale (CRS) technology and assumes that all DMUs operates under perfect competition. The CCR model is thus, appropriate for evaluating efficiency score of DMUs operating at optimal scale. The CCR model is primarily designed to evaluate the total technical efficiency of DMU by comparing the output to input ratio. The overall technical efficiency values are between zero and one. A DMU with a technical efficiency value of one is considered technically efficient, while those with a value less than one are technically inefficient. As the scale of operation remains constant, the CCR model's efficiency includes both the technical and scale efficiency measures.

The BCC model operates with respect to variable returns to scale (VRS) technology and assumes that DMUs are operating in an imperfectly competitive and financially constraint environment. The overall technical efficiency in the BCC model is comprised of two components: pure technical efficiency change and scale efficiency change. The BCC model is primarily used to evaluate the changes in pure technical efficiency and the efficacy of DMUs in converting inputs into outputs, regardless of operation scale. The impact of the scale of operation is the main source of inefficiency in the overall technical efficiency of DMUs in the BCC model.

Since the origin of the DEA methodology and development of fundamental DEA models, there has been a continuous progress in the development of new concepts and models in DEA theory. Many scholars have developed numerous DEA models with proper features and applications. The majority of the newly proposed DEA models are



the models that are extended and improved DEA versions of the CCR model and BCC model (Xu et al., 2020). In this study, we only emphasis on the Malmquist productivity index (MPI), which is the most widely applied and improved DEA model. MPI is a time series analysis technique for measuring the efficiency of DMUs by analyzing changes in production technology and innovation over the two different time intervals (Färe et al., 1994). The conventional DEA methods are static in nature, and they cannot assess the efficiency change in terms of frontier shift. Therefore, MPI is an extended and enhanced DEA model for evaluating the dynamic changes in efficiency frontier analysis.

### 3.2. Malmquist Productivity Index

Caves et al. (1982) proposed Malmquist Productivity Index (MPI) in 1982, and Färe et al. (1989) developed it further in 1989 as a nonparametric linear programming method for estimating efficiency and growth. The major applications of MPI were brought to light by the studies of Färe et al. (1992) and Färe et al. (1994). MPI consist of two main components: technical efficiency change and technological change. MPI (Malmquist, 1953) is a most effective method of measuring the productivity change using production function. MPI can be computed as output-oriented MPI or input-based MPI depending on the output and input distance functions. MPI can be constructed using input-output vectors of the production technology and scaling distance functions (Caves et al., 1982).

Let  $x_t = (x_1^t, x_2^t, \dots, x_n^t) \in R^N$  denote a vector of  $n$  inputs and  $y_t = (y_1^t, y_2^t, \dots, y_m^t) \in R^M$  be a vector of  $m$  outputs in time period  $t$ . The production technology  $P^t$  for each time period  $t = 1, 2, \dots, T$  is defined by,

$$P^t = \{(x^t, y^t): x^t \text{ can produce } y^t\}, \quad (1)$$

and  $P^t$  provides all possible combinations of input-output vectors that are technically feasible. Hence the output distance function on the technology is defined as,

$$D_o^t(x^t, y^t) = \min \{\theta: x^t, y^t/\theta \in P^t\} \quad (2)$$

The input distance function can be defined analogous to the output distance function.

MPI is defined based on the distance function for the reference technology using the observations at two different time periods,  $t$  and  $t+1$ . Let  $D_o^t(x^t, y^t)$  be the value of the output distance function for the technology from time period  $t$  and the input-output vector from the same time period. Similarly, the other output distance functions are expressed as  $D_o^{t+1}(x^{t+1}, y^{t+1})$ ,  $D_o^t(x^{t+1}, y^{t+1})$  and  $D_o^{t+1}(x^t, y^t)$ . The first one is related to the same time period and the last two are inter-temporal comparisons.

According to Caves et al. (1982) the output-based MPI for time period  $t$  is defined as,

$$M_o^t = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \quad (3)$$

and the output-based MPI for the time period  $t+1$  is given by,

$$M_o^{t+1} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \quad (4)$$

The MPI can be presented either as output oriented or input oriented. It is defined based on the objective of the decision-making units (DMUs) of which the productivity is to be measured. As propounded by Fare, Grosskopf, Lindgren and Roos [20], the output-oriented MPI in the time period  $t$  and  $t + 1$  is defined as the geometric mean of output-based MPI for the time period  $t$  and output-based MPI for the time period  $t + 1$

$$M^t(x^{t+1}, y^{t+1}, x^t, y^t) = \left[ \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \times \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \right]^{1/2} \quad (5)$$

Fare, Grosskopf, Lindgren and Roos (1994) suggested that the total factor productivity (TFP) can be decomposed into two components: technical efficiency change (TEC) and the technical change (TC). The technical efficiency change is the catching-up effect which measures the closeness of the DMU in the specific time period to the production frontier. Technical change is the frontier shift which measures the technological change between the time period. Nishimizu and Page [39] pointed out that productivity gain is not necessarily due to the technical change, and the productivity change can be achieved by increasing the technical efficiency. The productivity of a firm ultimately depends on the impact of scale size over production. The productivity can be improved and augmented only through technological development, improved operational efficiency and leveraging economies of scale. Thus, the technical efficiency change can be decomposed into two components as pure technical efficiency change (PTEC) and scale efficiency change (SEC). The pure technical efficiency results from improvements in management practices and the scale efficiency originate from the improvements towards optimal size of production.

The pure technical efficiency change (PTEC) is defined as,

$$\text{Pure Technical Efficiency Change (PTEC)} = \frac{D_{VRS}^{t+1}(x^{t+1}, y^{t+1})}{D_{VRS}^t(x^t, y^t)} \quad (6)$$

The PTEC compares the distance between DMU and production possibility frontier (PPF) in the specific time period in reference to variable returns to scale (VRS). If the distance between the DMU and the PPF has decreased over time, then the value of PTEC will be greater than unity. However, if the distance between the DMU and the PPF has increased over time, then the value of PTEC will be less than unity and if the distance remains the same then PTEC is equal to zero. Therefore, if the value of PTEC is greater than unity, then the DMU is more efficiently converting its input into output in time period  $t+1$  compared to time period  $t$ .

The scale efficiency change (SEC) is defined as,

$$\text{Scale Efficiency Change (SEC)} = \frac{D_{VRS}^t(x^t, y^t)}{D_{VRS}^{t+1}(x^{t+1}, y^{t+1})} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \quad (7)$$

The SEC measures the change in productivity of DMU due to the impact of change in scale of operation over the time. The DMU can increase their productivity by enhancing their scale of production. If the value of SEC is greater than unity, then the DMU is more scale efficient in time period  $t + 1$  compared to time period  $t$ . The increase in productivity of the DMU at time period  $t+1$  is may be due to operating at dismissing returns to scale rather than operating at increasing returns to scale. If SEC is less than unity, then the DMU is less scale-efficient in time period  $t + 1$  than time period  $t$ . The decrease in productivity of the DMU is due to the change in scale size. If SEC is equal

to unity, then the DMU's scale efficiency has remained same over the time. This implies that the impact of scale of operation on the productivity of DMU remain same over the time period.

The technical change (TC) is defined as,

$$\text{Technical Change (TC)} = \left[ \frac{D^t(x^t, y^t)}{D^{t+1}(x^t, y^t)} \times \frac{D^t(x^{t+1}, y^{t+1})}{D^{t+1}(x^{t+1}, y^{t+1})} \right]^{1/2} \quad (8)$$

The TC measures the frontier shift between the two different time period, showing technical progress or regress of the DMU. If the value of TC is greater than one, then it indicates technical progress. If TC is less than one, then it shows technical regress. If TC is equal to one, then there is no technical change. The technical progress indicates that more output can be produced at time period  $t + 1$  using the input of time period  $t$ .

Now,  $MPI = M^t(x^{t+1}, y^{t+1}, x^t, y^t)$  can be defined as,

$$MPI = M^t(x^{t+1}, y^{t+1}, x^t, y^t) = PTEC \times SEC \times TC \quad (9)$$

When MPI is greater than one ( $M^t > 1$ ), it indicates positive TFP growth from time period  $t$  to  $t+1$  and when MPI is less than one ( $M^t < 1$ ), it shows negative TFP growth from time period  $t$  to  $t+1$ . If MPI is equal to one ( $M^t = 1$ ), then it shows no change in TFP from time period  $t$  to  $t+1$ . The positive TFP growth indicates productivity gain and negative TFP growth shows productivity loss of the DMU.

#### 4. Data

This study focuses on the total population of 8 out of the 10 listed DHI-owned companies. The 8 selected DHI-Owned companies are namely Bhutan Power Corporation Ltd. (BPCL), Bhutan Telecom Ltd. (BTL), Drukair Corporation Ltd. (Drukair), Druk Green Power Corporation Ltd. (DGPC), Natural Resource Development Corporation Ltd. (NRDCL), Construction Development Corporation Ltd. (CDCL), Wood Craft Center Ltd. (WCCL) and State Mining Corporation Ltd. (SMCL). The two companies cannot be considered for the study one due to insufficient data and other being new to be included in the analysis. This study covers annual data from the period 2015 to 2018.

#### 5. Results and analysis

In order to analyse the sustainability performance using the Malmquist productivity index, we employed data envelopment analysis program (DEAP 2.1) to examine the timeline of changes of efficiencies over the period. DEAP 2.1 gives effch as Technical efficiency change, techch as Technological change, pech as pure technical efficiency change, sech as scale efficiency change and tfpch as total factor productivity change.

**Technical efficiency change:** Technical efficiency change shows the change in the amount of output produced from constant input due to change in output values. Drukair shows a maximum efficiency of 6.498 in 2016 followed by BPC (4.728), CDCL (3.073) but only BPC show an increase in technical efficiency in 2017 and other seven companies indicate a decrease in technical efficiency. However, in 2018 DGPC show a drastic increase to 2.435 whereas other companies have decreased.

**Technological Change:** It measures the notional level of output an organisation is able to produce will increase or decrease due to technological change resulting from the ability to optimally combine inputs and outputs. In 2016,



SMCL improved the performance by 87%, followed by Drukair and BTL. In 2017 SMCL has drastically improved, but Drukair need improvement of 41.8%. In 2018 NRDCL has to improve by 76.6% whereas the other seven companies are doing well.

*Pure technological change:* The PTEC compares the distance between DMU and production possibility frontier (PPF) in the specific time period in reference to variable returns to scale (VRS). In 2016, BPC is the most efficient and continued to be efficient until 2017. However, in 2018 it has reduced drastically to .180. In 2016 all companies are efficient with the all Pech value equal to unity or greater than unity. In 2017, DGPC have .625 which suggest lack of efficiency but other companies are all efficient. In 2018, three companies BPC, SMCL, and NRDCL are technically inefficient but other five companies are all efficient.

*Scale efficiency change:* The SEC measures the change in productivity of DMU due to the impact of change in scale of operation over the time. In 2016, four companies DGPC, BPC, WCCL and SMCL had same scale of operation as in 2015 but Drukair has increased the efficiency by 6 times and CDCL by 3 times. CDCL shows a decrease in scale efficiency in 2017 compared to 2016 by 38.8% and similarly, Drukair indicates reduction in scale efficiency by 62.6%. In 2018, all companies are scale efficient except CDCL which indicate an increase of 60.9% from the previous year.

*Total factor productivity change:* It indicate total output growth relative to the rise in input. It is a method of examining the production efficiency by keeping output independent of input. In 2016, the productivity growth of DGPC, BPC, NRDCL, CDCL, BTL and Drukair are 1.791, 1.996, 1.423, 2.038, 1.029 and 2.611 times more efficient compared to previous year 2015. In 2017, BPC is 6 times more efficient than the previous year and other companies are also indicates productivity growth. In 2018 DGPC was the most efficient company.

**Table 1.** Malmquist Index Summary

Year	Firm	Effch	Techch	Pech	Sech	Tfpch
2016	DGPC	1.829	0.979	1.829	1.000	1.791
	BPC	4.728	0.422	4.728	1.000	1.996
	WCCL	1.000	0.897	1.000	1.000	0.897
	SMCL	1.000	0.134	1.000	1.000	0.134
	NRDCL	1.994	0.713	1.000	1.994	1.423
	CDCL	3.073	0.663	1.000	3.073	2.038
	BTL	2.245	0.458	1.137	1.975	1.029
	Drukair	6.498	0.402	1.000	6.498	2.611
	Mean	2.296	0.507	1.331	1.726	1.163
2017	DGPC	0.625	1.191	0.625	1.000	0.745

	BPC	6.082	1.010	6.082	1.000	6.141
	WCCL	1.000	0.939	1.000	1.000	0.939
	SMCL	0.680	0.594	1.000	0.680	0.404
	NRDCL	1.000	1.729	1.000	1.000	1.729
	CDCL	0.622	0.906	1.000	0.622	0.563
	BTL	1.399	0.667	1.089	1.286	0.934
	Drukair	0.374	0.581	1.000	0.374	0.218
	Mean	0.979	0.894	1.194	0.819	0.875
2018	DGPC	2.435	2.445	2.435	1.000	5.955
	BPC	0.180	3.367	0.180	1.000	0.606
	WCCL	1.000	2.287	1.000	1.000	2.287
	SMCL	0.530	1.402	0.928	0.571	0.744
	NRDCL	0.478	0.234	0.840	0.569	0.112
	CDCL	1.609	1.145	1.000	1.609	1.842
	BTL	0.661	1.382	1.000	0.661	0.914
	Drukair	0.956	1.398	1.000	0.956	1.336
	Mean	0.761	1.386	0.874	0.871	1.055

SOURCE: Authors own.

**Table 2.** Malmquist Index Summary of Firm Means

Firm	Effch	Techch	Pech	Sech	Tfpch
DGPC	1.407	1.418	1.407	1.000	1.995
BPC	1.730	1.128	1.730	1.000	1.951
WCCL	1.000	1.244	1.000	1.000	1.244
SMCL	0.712	0.482	0.975	0.730	0.343
NRDCL	0.984	0.660	0.943	1.043	0.650
CDCL	1.454	0.883	1.000	1.454	1.283
BTL	1.276	0.750	1.074	1.189	0.958
Drukair	1.325	0.689	1.000	1.325	0.912
Mean	1.196	0.856	1.116	1.072	1.024

SOURCE: Authors own.

**Table 3.** Malmquist Index Summary of Annual Means

Year	Effch	Techch	Pech	Sech	Tfpch
2015-2016	2.296	0.507	1.331	1.726	1.163
2016-2017	0.979	0.894	1.194	0.819	0.875
2017-2018	0.761	1.386	0.874	0.871	1.055
Mean	1.196	0.856	1.116	1.072	1.024

SOURCE: Authors own.

## 6. Discussion

In Bhutan, corporate sustainability is well established from a social and environmental perspective. During the review of the company annual reports, the following indicators of social sustainability such as customer satisfaction survey, maintaining minimum wage, labour welfare, social commitment and corporate accountability with CSR and protection of human rights etc. were found in all companies. The training in human resource development was given to all workers by the concerned organization. All DHI-owned companies listed in the study have a website that provide all the requisite online documents and information, which is a sign of transparency and a significant indicator of corporate sustainability. In the environmental metric for corporate sustainability, all companies are supporting the government's sustainable environment initiatives. Bhutan Telecom encourages clients to use e-load instead of paper brochure, BOB encourages customers to use mBOB for paperless transactions and BPC online bill payments are some of the concrete initiatives taken to save the environment by DHI companies. The establishment of Bhutan's first disaster resilient emergency mobile network in Jakar, Bumthang for scaling up the sustainability of communication during the time of natural disasters by Bhutan telecom is also a good indicator of corporate sustainability. In brief, the organisations are performing the fiduciary duty of fulfilling and achieving the GNH objectives stated in the royal charter.

The output of eco-efficiency of corporate sustainability using MPI is appropriate for evaluating dynamic changes of efficiency of organisations. The advantage of this method is its ability to analyse factors that influence the efficiency of organisations which depends on technological improvement or change in management. In this study, we found that between the period 2015 and 2018, the management efficacy plays a vital role in 2016 and technology improvement in 2018. The mean total factor productivity, technological change, and the technical efficiency change were 1.024, 0.856 and 1.196 (Table 3) respectively. Technical efficiency indicates efficiency change due to cutting edge technology or also called 'frontier mobile' or development in technology and innovation. In this study only three companies: DGPC, BPC, and WCCL indicated improvement in innovation and technical progress with 41.8%, 12.8% and 24.4% respectively. The largest technological change is 41.8% of DGPC and least is 12.8% of BPC. The technological efficiency change in organisation is attributed to technological change from  $t$  to  $t+1$  year. It is observed that the average technological change is less than one, which indicates lack of technological development and innovation in the companies owned by DHI. From the eight DHI-owned companies, only three

exhibits technological growth. Thus, DHI-owned companies have to focus on technological development and innovations in order to enhance eco-efficiency. DGPC and BPC are the best performing companies with the total factor productivity index of 1.995 and 1.951 (Table 2) respectively. DGPC and BPC are thus showing high technological, innovation and managerial proficiencies. Optimal use of technology and management practices is observed in WCCL with total factor productivity index of 1.244. The 1.283 total factor productivity of NRDC is largely attributed to technical efficiency change. SMCL and NRDC require improvement in management practices and as well as in technology as both technical efficiency change and technical change indices are less than one. The technical change index of Drukair is 0.689 and this indicates the need to boost technological innovation as the total factor productivity index has been reduced to 0.912. The BTL also exhibits the similar results of Drukair. Thus, Drukair and BTL should focus on improving the technological facets to gain improvement in technical change index.

## 7. Conclusion

The study shows that DGPC, BPC, CDCL and WCCL's TFP growth discretely correspond to 99.5%, 95.1%, 28.3% and 24.4%. The productivity growth in DGPC, BPC, and WCCL are attributed to increase in technical efficiency and technological change which indicates a sustainable growth. The productivity growth in CDCL was driven by technical efficiency which is a short term growth. It was observed that all other four companies SMCL, BTL, Drukair and NRDC experienced productivity regress during the period of 2015 to 2018. The empirical findings suggest that BTL and Drukair's productivity regress are attributed to the technological regress. However, SMCL and NRDC's productivity regress are ascribed to both efficiency regress and technical regress. In contrast, we observe that increase in technical efficiency outweighs the regress in technological change of the DHI companies and consequently had positive impact on the overall productivity of DHI companies. The overall changes in pure technical efficiency and scale efficiency was observed to have positive growth with values 11.6 percent and 7.2 percent, respectively. The overall technological efficiency change has regressed with 14.4 percent. Thus, the productivity growth in DHI companies is mainly attributed to technical improvements and not to technological advancements. The technological inefficiency was the main source of inefficiency in DHI companies. The average TFP growth rate is observed to fluctuate from 16.3 % in 2015-16 to negative 12.5 % in 2016-17 and again to 5.5% in 2017-18. This indicates that, in order to be competitive and sustainable, companies should adopt and implement quality management practices and technological acquisition and innovation.

## 8. Future Directions

1. Extend the study period beyond 2018 to evaluate if the observed trends in efficiency and productivity continue over a longer period.
2. Analyze the influence of external factors such as economic conditions, regulatory changes, and market dynamics on the operational sustainability of DHI companies.
3. Perform a more detailed analysis of the components of pure technical efficiency, technological efficiency, and scale efficiency to identify specific areas for improvement.
4. Incorporate additional sustainability metrics such as environmental impact, social responsibility, and

governance practices to provide a more comprehensive evaluation of corporate sustainability performance.

5. Conduct qualitative research to gather insights from stakeholders, including employees, customers, and community members, on the sustainability practices of DHI companies.

6. Explore the use of other productivity and efficiency measurement techniques to validate and complement the findings obtained from DEA and the Malmquist productivity index.

7. Develop and test new models that can better capture the complexities and nuances of corporate sustainability performance.

## Declarations

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### Competing Interests Statement

The authors declare having no competing interest with any party concerned during this publication.

### Consent for Publication

The authors declare that they consented to the publication of this study.

### Authors' contributions

Both the authors made full contribution starting from proposal writing, visualization, methodology, data analysis, first draft writing, review and editing.

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